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CASE SERIES

MANAGEMENT OF ACUTE GRADE II LATERAL ANKLE SPRAINS WITH AN EMPHASIS ON LIGAMENT PROTECTION: A DESCRIPTIVE CASE SERIES

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ABSTRACT

Background and Purpose: Lateral ankle sprain the most common injury in physically active populations. Individuals who sustain an acute lateral ankle sprain may not receive timely formal rehabilitation and are at an increased risk to have subsequent sprains which can lead to chronic pain and instability. Attention to essential factors for ligament protection and healing while preserving ankle movement, may result in a more stable yet mobile ankle offering improved outcomes. The purpose of this case series was to describe the methods and observe the outcomes associated with a comprehensive strategy for managing acute first episode grade II lateral ankle sprains.

Study design: Prospective case series.

Case Descriptions and Interventions: Ten patients (mean age 26.7 years, range 16-51 years, mean 2.3 days from injury) with acute grade II lateral ankle sprain were treated with an approach to protect the injured ligament, prevent impairments to movement, restore strength and proprioception, and progress to full function. Patient outcomes were assessed at four, eight and 12 weeks. Follow-up interviews at six and 12 months assessed injury recurrence.

Outcomes: Patients were treated for an average of eight sessions over a mean of seven weeks. Rapid change in self-reported function, ankle ROM, and pain were observed in the first four weeks of care. Clinically meaningful improvements in function and ankle ROM were also noted at eight weeks and maintained at 12-week follow-ups. All patients returned to desired physical activity with only a single re-sprain event within one year after injury.

Conclusion: The results of this prospective case series suggest that a treatment approach designed to protect the injured ligament, maintain and restore normal ankle motion, and provide a tailored functional pathway to return to run and sport demonstrated resolution of symptoms and improvement in reported functional outcomes in a group of patients following grade II acute primary ankle sprain.

Level of Evidence: Level IV, Case Series

Key Words: Ankle sprain, joint mobilization, rehabilitation, movement system

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The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Departments of the Army or Defense.

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BACKGROUND AND PURPOSE

Lateral ankle sprains (LAS) are one of the most common injuries sustained during sport and exercise among active teenagers and young adults.[1,2] Most patients with LAS do not receive supervised rehabilitation and the majority of costs associated with LAS come from physician evaluations.[3] Athletes typically return to sport within 3-21 days, well before full ligament healing and recovery,[4,5] and 30-70% of patients report subsequent ankle sprains within one year of their initial injury,[6-8] and 45% report incomplete recovery three years after injury.[3] Prognosis of lateral ankle sprains primarily relates to the extent of injury and potentially to how the injury is managed.[9] Given the relationship between prognosis and degree of injury, appropriately grading lateral ankle sprains may assist in injury management. Recent clinical practice guidelines (CPG) for ankle sprains recommend an ankle sprain grading scale that uses a constellation of clinical findings which includes: loss of function, ligamentous laxity, presence of bruising, point tenderness, loss of motion, and amount of swelling (Table 1).[8,10] Repeated ankle sprains can lead to chronic ankle instability (CAI), osteochondral defects, and articular cartilage alterations that may eventually result in ankle OA, decreased participation in physical activity, and lower quality of life.[11-13]

Primary or first episode grade II LAS are important injuries providing an opportunity for a management approach to be implemented that prioritizes ligament protection during the early phases of healing and restoration of movement to prevent CAI, OA, and disability.[8,9] Recommendations for the management of acute ankle sprains include functional support using a brace,[14,15] manual therapy,[16,17] exercises for strength and range of motion (ROM),[16,18] and proprioceptive training.[19] In the clinic each of these treatments is typically progressed based on subjective estimates of the patient's activity tolerance with an overall goal of early return to full activity, including sports.[5] However, the repair and remodeling process of an injured tissue may be much slower than the patient's typical functional progression which is largely driven by the patient's desire to return to activity and competition.[20,21] In the largest acute ankle sprain study to date, Brison et al. investigated standardized physical therapy procedures not utilizing specific ligament protection and healing measures and found no difference between physical therapy and usual medical care.[22] These findings suggest that either the injury has an unfavorable prognosis regardless of management or the essential aspects of treatment that would improve outcomes were missing in both physical therapy and usual medical care.

There is a predictable healing pathway after ligamentous injury that includes an acute inflammatory phase, proliferative phase, and a remodeling phase that increases tensile properties.[21] Although evidence from ankle ligament specific healing studies is very limited, acute ankle sprains should be managed in a manner consistent with the general knowledge of proper management of ligamentous injury. For example, controlled ROM through bracing is a foundational strategy for managing a tear to the medial collateral ligament of the knee.[23] This

Table 1. *Ankle Sprain Grading Scale Proposed by Malliaropoulos et al. 2009*

Grade I	Grade II	Grade III
• No loss of function • No ligamentous laxity with anterior drawer and talar tilt testing • Little or no bruising • No point tenderness • Decreased total ankle motion of 5 degrees or less • Swelling of 0.5 cm or less as measured by figure-of-eight testing	• Some loss of function • Positive anterior drawer test, negative talar tilt test • Bruising • Point tenderness • Decreased total ankle motion > 5 degrees but < 10 degrees • Swelling > 0.5 cm but < 2.0 cm	• Near total loss of function • Positive anterior drawer and talar tilt test • Bruising • Extreme point tenderness • Decreased total ankle motion > 10 degrees • Swelling >2.0 cm

protects the healing ligament, promotes regular arrangement of healing fibers and limits disruptive valgus force.[23] In contrast, when the anterior talofibular ligament of the ankle is injured in a lateral ankle sprain, patients are typically braced for short periods and given exercises that do not carefully control the extent of inversion potentially overly stressing and stretching healing tissue.[24] Studies on ATFL strain using stress ultrasonography have found that when the ankle is placed into a position of inversion, 12 degrees plantarflexion and 25 degrees of internal rotation, the ATFL becomes taut.[25] Some tightening and movement of healing ligaments has been shown in a variety of studies to improve healing,[23,26,27]which may be accomplished through painfree dorsiflexion and plantarflexion, while avoiding movement into the direction of the injuring mechanism (inversion) may reduce adverse stress to the healing structures. The proliferative phase after ligament injury can last for weeks to several months during which time the healing ligament remains mechanically weak and subject to reinjury.[21]

Careful clinical decisions are required to provide the activity limitations and bracing to protect the injured ankle from further injury while providing the balance of rehabilitation stimuli to maintain normal ankle motion and restore the required strength and balance for higher levels of sport and activity. Injured ligaments require protection against excess strain forces for 6-12 weeks for moderate healing and more than one year for complete healing to occur.[20,28] This time frame is based on tissue healing and extent of injury, which can be influenced by numerous variables such as age, the quality of the tissue at injury, nutrition, medications, environmental factors, healing stimuli and adverse stimuli. Inconsistent with this evidence, return to activity is frequently allowed much earlier after acute lateral ankle sprain.[3,5,24,23,26,29,30,31]

The purpose of this case series was to describe the methods and observe the outcomes associated with a comprehensive strategy for managing acute first episode grade II lateral ankle sprains. This strategy was specifically designed to be conservative in order to prioritize protection of the injured ligament, restore and maintain normal motion, and provide a tailored functional pathway to return to run and sport.

CASE DESCRIPTIONS

The Brooke Army Medical Center Institutional Review Board in Fort Sam Houston, TX reviewed the protocol for this study and informed consent was obtained from the participants prior to data collection. Consecutive patients with acute primary grade II lateral ankle sprains[8,10] either referred from the local emergency department or a direct access physical therapy clinic were consented and enrolled. All patients were screened, examined, and treated by a physical therapist board certified in sports physical therapy. Patients met the inclusion criteria if they presented with an acute[8] grade II lateral ankle sprain, reported no previous ankle sprain on the affected side, were either negative on the Ottawa Ankle rules[32] or had a negative radiographic study, and had sufficient English language skills to complete the outcome instruments. Patients were excluded if their clinical examination was consistent with a grade I, III, deltoid ligament or a tibiofibular syndesmosis sprain,[33,34] there was identification of a fracture to the affected ankle or foot, the injury was subacute or chronic, if they were unable to commit to the course of care, or were pregnant. Twelve consecutive patients with acute grade II lateral ankle sprains were screened for eligibility according to the inclusion and exclusion criteria. Two choose not to participate due to the time requirement. Ten patients agreed to participate (mean age 26.7, range 16-51 years; 70% female). Of the ten participants, six were screened in a direct access physical therapy clinic and four were referred from the local emergency department.

Upon enrollment, each subject underwent a patient-focused interview to determine the location and behavior of symptoms in addition to relevant details of the current injury and any previous injuries and existing conditions. The information obtained from the interview facilitated understanding of the patient's likely tolerance to examination and treatment and facilitated forming the diagnostic hypotheses used to plan, tailor, and conduct the examination.

Following the interview, each patient underwent a thorough examination of the lower quarter including careful palpation of injured and potentially injured structures, assessment of swelling, ligamentous special tests, physiologic active and passive range of motion, passive accessory motion, soft tissue

mobility, gait, balance, and strength. Grade of ankle sprain was determined through clinical evaluation using the grading scale developed by Malliaropoulos et al[10] and recommended for use in the ankle instability CPG (Table 2).[8] Day one treatment focused on protecting the injured ligament, reducing swelling, initiating active range of motion (AROM) into pain-free dorsiflexion and plantarflexion, and normalizing gait using crutches if the gait was antalgic. Patients were carefully educated on the purpose of each of these intervention strategies in addition to use of rest, ice, compression, elevation (RICE),[35] brace wear, and the initial home exercise program.

Identified impairments of strength, movement, and gait determined the focus of treatment at each clinical session. Based on current limited understanding of ankle ligament healing after acute injury,[20] all patients were instructed to avoid active inversion for six weeks to avoid disruptive stress to the injured tissue. From weeks 6-12, patients were encouraged to add gentle to moderate pain free inversion movements in various positions of PF and DF to provide progressive ROM to the ankle and moderate controlled tensile force to the healing ligament. Furthermore, patients were asked to wear a lace up ankle brace (Procare® lace up ankle support, DJO LLC, Vista, CA) throughout the entire day for twelve weeks. Patients then transitioned to wearing the brace for sports, running or walking on uneven ground, and as needed for other physical activity for one year after initial injury.

The utilized intervention strategies had overlapping effects that helped to simultaneously address multiple goals. For example, early appropriately guided and dosed ankle motion helped to maintain and regain ankle movement, normalize gait, and reduce ankle swelling. Too frequent or too high of a dose of movement exercise or walking could increase swelling and inflammation thereby working against normal painless movement, normal gait, and return to higher level activities. Appendix A presents the management strategies used in this case series.

Patient self-reported outcomes included the Foot and Ankle Ability Measure (FAAM) Activity of Daily Living (ADL) and Sport subscales[36] and the Numeric Pain Rating Scale (NPRS).[37-39] The FAAM is a reliable, responsive, and valid region specific self-reported measure of function and the NPRS is a reliable, responsive, and valid measure of pain sensation intensity.[36,38,39] Physical performance assessments included the Ankle Lunge Test (ALT) for dorsiflexion ROM[40-45] and the Y-Balance Test (YBT).[46-49] The ALT is a weight bearing measurement of ankle dorsiflexion and has excellent intra and inter-rater reliability.[41] The YBT is used to assess lower extremity balance and neuromuscular control to predict lower extremity injury and has good inter-rater test-retest reliability with an acceptable level of measurement error.[48] All self-report outcome measures and the ALT were completed at baseline, four weeks, eight weeks, and 12 weeks. The YBT was not completed at baseline in order to limit stress on the acutely injured ankle. Therefore, the YBT was completed at four weeks, eight weeks, and 12 weeks follow-up. Patients also underwent six and 12-month telephone follow-up interviews to assess for injury recurrence.

Table 2. *Patient demographics.*

Patient Demographics								
Patient	Age (yrs)	Height (in)	Weight (lbs)	Gender	Side of sprain	Time Until Initial Evaluation (hrs)	Number of Visits	Duration of Care (days)
1	19	58	107	Female	Right	24	8	54
2	26	76	225	Male	Left	10	8	53
3	37	62	125	Female	Right	72	5	35
4	23	64	140	Female	Left	48	9	56
5	18	72	155	Male	Right	12	8	53
6	51	61	161	Female	Right	72	8	55
7	16	66	139	Female	Right	120	8	52
8	20	65	123	Male	Right	24	9	55
9	24	67	153	Female	Left	120	10	62
10	33	62	192	Female	Left	48	7	46
Mean	26.7	65.3	152	F-7, M-3	R-6, L-4	55	8	52

OUTCOMES

Patients started treatment an average of 2.3 days following injury (range 1-5 days) with an average of eight clinical visits over 6-9 weeks. All patients completed the entirety of treatment and follow up evaluations. At the one-year follow-up, nine patients reported no recurrence of injury, continued with brace wear during physical activity, could return to full participation in their desired activity, and required no further medical care after discharge from physical therapy. Patient 2 reported a minor re-sprain of his affected ankle before the six-month follow-up sustained while sprinting on an uneven surface without his ankle brace. He was able to self-manage his re-sprain based on the education provided throughout his course of care and did not require further medical or physical therapy services.

Patient compliance with brace use, ROM limitations, and treatment recommendations were assessed at each visit through questioning and inspection of the exercise log. Full compliance was defined as adhering to treatment recommendations 85-100% of the time, moderate compliance was defined as 50-75% adherence, and low compliance was defined as 0-50% adherence to treatment recommendations. Six of ten patients reported wearing their braces during all waking hours, three patients displayed moderate compliance (50-75% of the day) to brace recommendations, patient 8 spent less than 25% of the day wearing the brace. All patients reported full compliance with avoidance of ankle inversion until after six weeks.

Patients who were compliant with brace and ROM recommendations also tended to be most compliant with their home exercise programs. Exercise compliance was assessed at each visit during the interview and by reviewing the exercise log. Five patients were fully compliant, three patients were moderately compliant, and two patients were minimally compliant with the recommended dosage and frequency to their HEP throughout the course of care. The most common stated reason for decreased compliance was due to a perceived lack of time to perform the two to four exercises requiring 15-20 minutes per day.

At intake, all patients demonstrated moderate self-reported disability based on FAAM ADL scores (mean 63%, range 43-92%). All patients demonstrated clinically meaningful improvement at four weeks (mean 94%, range 87-100%) and those changes persisted to the 12 week follow up (mean 99%, range 94-100%) (Table 3). Self-reported disability based on FAAM sport was higher at intake (mean 24%, range 0-71%) compared to FAAM ADL scores (Figure 1). All but patient 7 demonstrated clinically meaningful improvements at four weeks (mean 56%, range 13-100%) and at eight weeks (mean 84%, range 43-100%). Potentially explaining the slower progress, in addition to the ankle sprain, patient seven presented with a pre-existing metatarsal stress fracture on her contralateral foot, which also limited her participation in functional activities.

It is worth noting that those who were fully compliant with their home exercise program and were at least moderately compliant with brace wear and avoidance of inversion all achieved 100% on the FAAM sports subscale at 12 weeks (mean 91%, range 75-100%), excluding patient 7 with the contralateral metatarsal stress fracture. Patients 2 and 5 reported 100% at eight weeks on both the FAAM ADL and sports subscales. There were no significant findings to suggest why they improved earlier, other than they both were evaluated and began treatment within 10-12 hours of injury.

Clinically meaningful improvements in pain, ROM, and balance were also seen in secondary outcome measures. Average pain scores measured by the NPRS improved at four weeks (mean 0, range 0-3) compared to baseline (mean 5, range 1-7) and this improvement was maintained at eight weeks and 12 weeks (Figure 2). Patients 3 and 8, who demonstrated poor compliance to their home exercise program, reported minimal (3/10 and 1/10, respectively) pain at 12 weeks, suggesting less than full compliance still resulted in positive outcomes, albeit less than the remainder of the cohort.

There was substantial improvement in mean ankle dorsiflexion ROM at the four week follow-up in all patients. Mean ALT was 2.3 cm (range -2-10 cm) at baseline on the injured ankle and increased to 8.8 cm (range 4-16 cm) at four weeks, which exceeded the MDC of 1.9 cm. This improvement was maintained at eight weeks and by 12 weeks (mean 10.7, range

Table 3. *Outcome Measures at Baseline and at 4, 8, and 12 Weeks Post Baseline.*

Outcome Measures at Baseline and at 4, 8, and 12 Weeks Post Baseline							
Patient	Time Point	FAAM ADL	FAAM Sport	NPRS	ALT (cm)	YBT Ant Reach Injured Ankle (cm)	YBT Ant Reach Uninjured Ankle (cm)
1	Baseline	56%	54%	7	2		
	4 Wk	98%	79%	1	8	46.5	48
	8 Wk	98%	100%	0	7.5	54.5	55.5
	12 Wk	100%	100%	0	8	47.5	44.5
2	Baseline	43%	14%	4	3		
	4 Wk	96%	75%	0	16	52	73
	8 Wk	100%	100%	0	18	67.5	72.5
	12 Wk	100%	100%	0	19	67	64.5
3	Baseline	57%	7%	4	2		
	4 Wk	87%	32%	2	7	52	52
	8 Wk	86%	75%	0	9.5	52.5	56.5
	12 Wk	94%	82%	3	9	51.5	52.5
4	Baseline	86%	41%	4	5.5		
	4 Wk	95%	82%	1	11	47.5	59
	8 Wk	98%	100%	0	14	54	60
	12 Wk	99%	100%	0	13	54.5	52.5
5	Baseline	52%	25%	3	10		
	4 Wk	100%	100%	0	12.5	66.5	64.45
	8 Wk	100%	100%	0	12.5	74	74.5
	12 Wk	100%	100%	0	12	67.5	71
6	Baseline	55%	0%	7	0		
	4 Wk	93%	29%	0	6	42.5	43.5
	8 Wk	100%	75%	0	7.5	47	45.5
	12 Wk	100%	100%	0	8	48.5	47
7	Baseline	85%	71%	1	3		
	4 Wk	87%	75%	0	9	52	62
	8 Wk	93%	71%	0	11	57.5	62.5
	12 Wk	100%	82%	0	11	62.5	61.5
8	Baseline	92%	30%	5	0		
	4 Wk	96%	54%	1	7	42	53
	8 Wk	100%	91%	0	10.5	47	55
	12 Wk	100%	75%	1	12	49.5	56
9	Baseline	64%	0%	3	-1		
	4 Wk	88%	18%	0	4	42.5	46.5
	8 Wk	93%	43%	0	4	45.5	49
	12 Wk	98%	75%	0	6	53.5	50.5
10	Baseline	43%	0%	7	-2		
	4 Wk	95%	13%	0	7	41	49
	8 Wk	91%	88%	0	8	48	47.5
	12 Wk	100%	100%	0	8.5	48	51
Mean	Baseline	63%	24%	5	2.3		
	4 Wk	94%	56%	1	8.8	48.5	55.1
	8 Wk	96%	84%	0	10.3	54.8	57.9
	12 Wk	99%	91%	0	10.7	55	55.1

6-19 cm) the MDC was exceeded again compared to the four week follow-up (Figure 3). All patients normalized their ankle range of motion by 12 weeks.

Baseline YBT measurements were first obtained at four weeks. Mean anterior reach on the injured ankle was 48.5 cm (range 41-66.5 cm) compared to 55.1 cm (range 43.5-73 cm) on the uninjured ankle at 4 weeks. Six patients exceeded the MDC of ≥4 cm asymmetry between limbs on the anterior reach. At eight weeks and 12 weeks measurements of mean anterior reach were within normal limits among all patients except

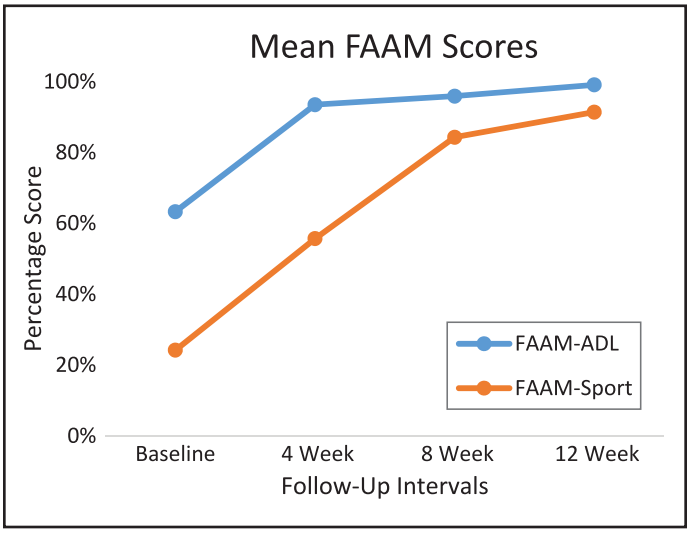


Figure 1. *Mean Foot and Ankle Ability Measure (FAAM) scores (ADL and sport). The ADL and sport subscales gives a maximum score of 100% with the higher score meaning less disability.*

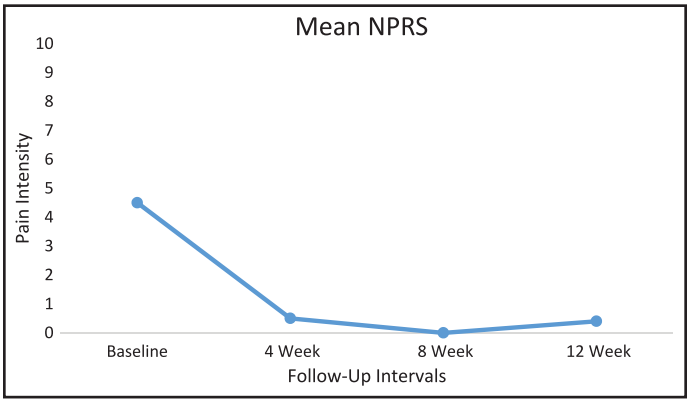


Figure 2. *Mean Numeric Pain Rating Scale (NPRS) scores. The NPRS is an 11-point scale, ranging from zero to 10, with 10 being the most intense pain.*

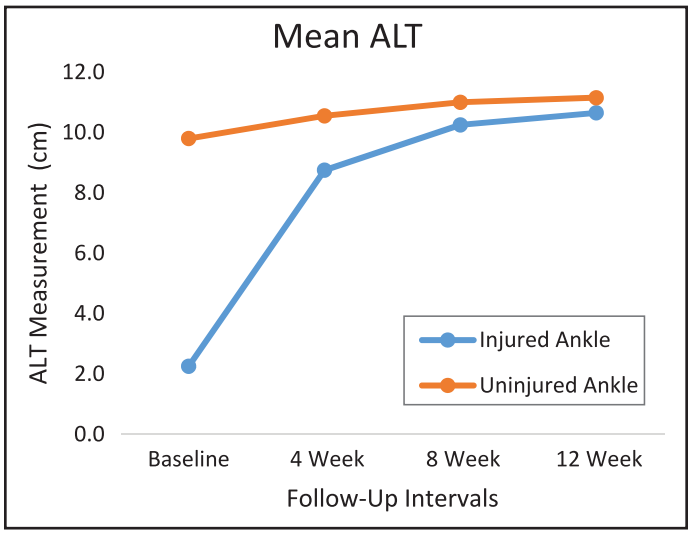


Figure 3. *Mean ALT scores (injured and uninjured ankles). The ALT is a weight bearing measurement of ankle dorsiflexion.*

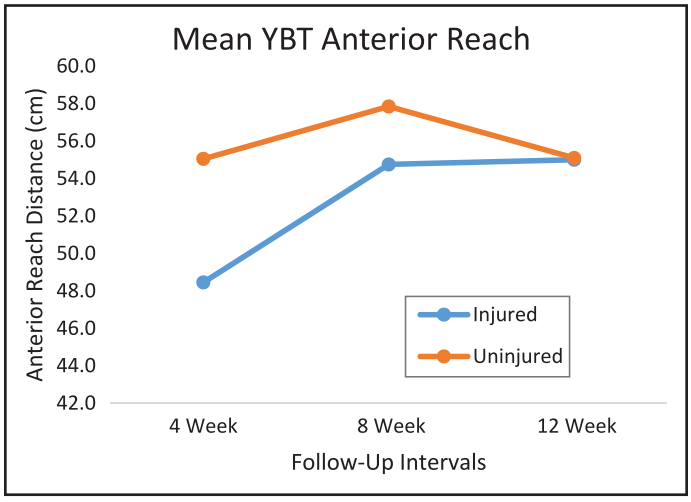


Figure 4. *Mean Y-Balance Test anterior reach (injured and uninjured ankles).*

for patient 8, who exceeded the MDC for between limb asymmetry at 12 weeks (Figure 4). This is meaningful as patients who have 4 cm or greater limb asymmetry on the anterior reach portion are over two times more likely to sustain a lower extremity injury.[43,45,46] Mean composite scores (injured/ uninjured) at four, eight, and 12 week follow-ups were 83.7 (range 73.3-93.8)/ 88.3 (range 72.1-101.7), 90.6 (range 76.1-102)/ 93.5 (range 84.7-102.6), and 90.2 (range 76.7-108.3)/ 91 (range 81.4-104.9) respectively (Figure 5).

DISCUSSION

These outcomes suggest that a comprehensive clinical strategy for patients with acute primary grade II lateral ankle sprains with an emphasis on requirements for ligament protection while maintaining range of motion and timing appropriate return to function with patient tailored treatment and activity is promising and merits further study. The prolonged bracing and limitation of inversion used in this case series is novel and counter to current recommendations.[8,50] A more conservative and evidence-based approach to facilitate ligament protection was not observed to have an adverse influence on ankle motion and function. At 12 weeks, clinical measures demonstrated symmetrical ankle dorsiflexion, and symmetrical balance scores. All patients reported

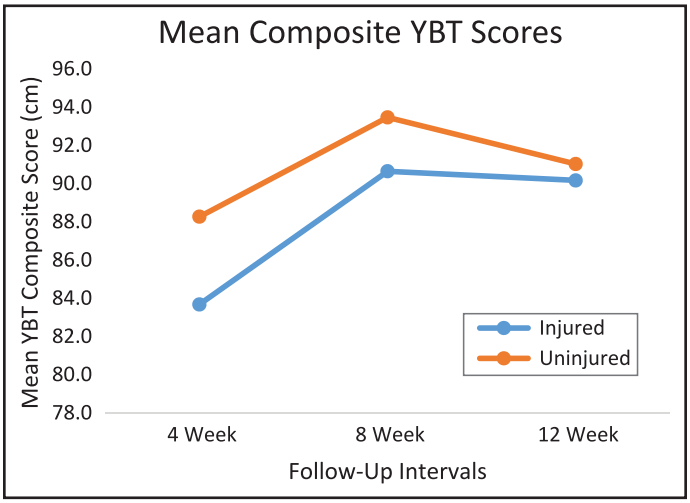


Figure 5. *Mean composite Y-Balance Test scores (injured and uninjured ankles). Composite scores are the sum of the 3 reach directions divided by 3 times leg length, then multiplied by 100. This permits reach distance to be normalized to leg length, allowing comparison between subjects.*

near full levels of self-reported function and no activity limiting pain. All patients had returned to their pre-injury level of activity with no re-injuries, and no subjective instability or giving way. At one year post injury, only one patient reported an additional minor ankle sprain.

The short period of time from injury to initiating physical therapy care (mean of 2.3 days) may be an important factor in the management of these acute ankle sprains. This timing allowed for early management during the inflammatory phase of healing and guidance when transitioning into the proliferative phase. By giving patients timely instruction on how to protect the injured ligament, control swelling, normalize gait, and promote ROM without straining injured tissue, the early healing could be facilitated without delay and further impairments may have been avoided.

After ligament protection, normalization of ankle ROM and gait was the primary treatment priority. Limited dorsiflexion following an ankle sprain is a known risk factor for recurrent injury[51] and pain with dorsiflexion ROM at four weeks is a prognostic indicator for function at four months.[52]

Limitations to this case series include an inability to draw cause-effect conclusions whether the observed outcomes were due to the special attention to protecting the injured ankle or maintaining joint ROM or any aspect of the management. The contribution of any of the factors or combination of any factors to the recovery process cannot be determined from this case series. The low number of cases observed is also an inherent limitation in case series research. Randomized clinical trials are needed to accurately determine the effectiveness of this treatment approach.

CONCLUSION

The results of this prospective case series suggest that a treatment approach designed to protect the injured ligament, maintain and restore normal ankle motion, and provide a tailored functional pathway to return to run and sport demonstrated resolution of symptoms and improvement in reported functional outcomes in a group of patients following grade II acute primary ankle sprains.

REFERENCES

1. Gribble PA, Bleakley CM, Caulfield BM, et al. 2016 consensus statement of the International Ankle Consortium: prevalence, impact and long-term consequences of lateral ankle sprains. *Br J Sports Med.* 2016;50(24):1493-1495.
2. Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ, Jr. The epidemiology of ankle sprains in the United States. *J Bone Joint Surg Am.* 2010;92(13):2279-2284.
3. Feger MA, Glaviano NR, Donovan L, et al. Current Trends in the Management of Lateral Ankle Sprain in the United States. *Clin J Sport Med.* 2017;27(2):145-152.
4. Nelson AJ, Collins CL, Yard EE, Fields SK, Comstock RD. Ankle injuries among United States high school sports athletes, 2005-2006. *Journal of athletic training.* 2007;42(3):381-387.
5. Medina McKeon JM, Bush HM, Reed A, Whittington A, Uhl TL, McKeon PO. Return-to-play probabilities following new versus recurrent ankle sprains in high school athletes. *Journal of science and medicine in sport / Sports Medicine Australia.* 2014;17(1):23-28.
6. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. *British journal of sports medicine.* 2001;35(2):103-108.
7. Doherty C, Delahunt E, Caulfield B, Hertel J, Ryan J, Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. *Sports medicine.* 2014;44(1):123-140.

8. Martin RL, Davenport TE, Paulseth S, Wukich DK, Godges JJ. Ankle stability and movement coordination impairments: ankle ligament sprains. *The Journal of orthopaedic and sports physical therapy.* 2013;43(9):A1-40.
9. Malliaropoulos N, Ntessalen M, Papacostas E, Longo UG, Maffulli N. Reinjury after acute lateral ankle sprains in elite track and field athletes. *The American journal of sports medicine.* 2009;37(9):1755-1761.
10. Malliaropoulos N, Papacostas E, Papalada A, Maffulli N. Acute lateral ankle sprains in track and field athletes: an expanded classification. *Foot Ankle Clin.* 2006;11(3):497-507.
11. Valderrabano V, Hintermann B, Horisberger M, Fung TS. Ligamentous posttraumatic ankle osteoarthritis. *The American journal of sports medicine.* 2006;34(4):612-620.
12. Harrington KD. Degenerative arthritis of the ankle secondary to long-standing lateral ligament instability. *The Journal of bone and joint surgery. American volume.* 1979;61(3):354-361.
13. Golditz T, Steib S, Pfeifer K, et al. Functional ankle instability as a risk factor for osteoarthritis: using T2-mapping to analyze early cartilage degeneration in the ankle joint of young athletes. *Osteoarthritis and cartilage / OARS, Osteoarthritis Research Society.* 2014;22(10):1377-1385.
14. Lamb SE, Marsh JL, Hutton JL, Nakash R, Cooke MW. Mechanical supports for acute, severe ankle sprain: a pragmatic, multicentre, randomised controlled trial. *Lancet.* 2009;373(9663):575-581.
15. Bellows R, Wong CK. THE EFFECT OF BRACING AND BALANCE TRAINING ON ANKLE SPRAIN INCIDENCE AMONG ATHLETES: A SYSTEMATIC REVIEW WITH META-ANALYSIS. *International journal of sports physical therapy.* 2018;13(3):379-388.
16. Cleland JA, Mintken PE, McDevitt A, et al. Manual physical therapy and exercise versus supervised home exercise in the management of patients with inversion ankle sprain: a multicenter randomized clinical trial. *The Journal of orthopaedic and sports physical therapy.* 2013;43(7):443-455.
17. Loudon JK, Reiman MP, Sylvain J. The efficacy of manual joint mobilisation/manipulation in treatment of lateral ankle sprains: a systematic review. *British journal of sports medicine.* 2014;48(5):365-370.
18. Lin CW, Hiller CE, de Bie RA. Evidence-based treatment for ankle injuries: a clinical perspective. *The Journal of manual & manipulative therapy.* 2010;18(1):22-28.
19. Postle K, Pak D, Smith TO. Effectiveness of proprioceptive exercises for ankle ligament injury in adults: a systematic literature and meta-analysis. *Manual therapy.* 2012;17(4):285-291.
20. Hubbard TJ, Hicks-Little CA. Ankle ligament healing after an acute ankle sprain: an evidence-based approach. *Journal of athletic training.* 2008;43(5):523-529.
21. Cottrell JA, Turner JC, Arinzeh TL, O'Connor JP. The Biology of Bone and Ligament Healing. *Foot Ankle Clin.* 2016;21(4):739-761.
22. Brison RJ, Day AG, Pelland L, et al. Effect of early supervised physiotherapy on recovery from acute ankle sprain: randomised controlled trial. *BMJ.* 2016;355:i5650.
23. Reider B, Sathy MR, Talkington J, Blyznak N, Kollias S. Treatment of isolated medial collateral ligament injuries in athletes with early functional rehabilitation. A five-year follow-up study. *The American journal of sports medicine.* 1994;22(4):470-477.
24. Mattacola CG, Dwyer MK. Rehabilitation of the Ankle After Acute Sprain or Chronic Instability. *Journal of athletic training.* 2002;37(4):413-429.
25. Wiebking U, Pacha TO, Jagodzinski M. An accuracy evaluation of clinical, arthrometric, and stress-sonographic acute ankle instability examinations. *Foot and ankle surgery : official journal of the European Society of Foot and Ankle Surgeons.* 2015;21(1):42-48.
26. Buckwalter JA. Should bone, soft-tissue, and joint injuries be treated with rest or activity? *Journal of orthopaedic research : official publication of the Orthopaedic Research Society.* 1995;13(2):155-156.
27. Hart DP, Dahners LE. Healing of the medial collateral ligament in rats. The effects of repair, motion, and secondary stabilizing ligaments. *The Journal of bone and joint surgery. American volume.* 1987;69(8):1194-1199.
28. Hubbard TJ, Cordova M. Mechanical instability after an acute lateral ankle sprain. *Arch Phys Med Rehabil.* 2009;90(7):1142-1146.
29. Martinez DA, Vailas AC, Vanderby R, Jr., Grindeland RE. Temporal extracellular matrix adaptations in ligament during wound healing and hindlimb unloading. *American journal of physiology. Regulatory, integrative and comparative physiology.* 2007;293(4):R1552-1560.
30. Jones RE, Henley MB, Francis P. Nonoperative management of isolated grade III collateral ligament injury in high school football players. *Clin Orthop Relat Res.* 1986(213):137-140.
31. Burroughs P, Dahners LE. The effect of enforced exercise on the healing of ligament injuries. *The American journal of sports medicine.* 1990;18(4):376-378.

32. Jonckheer P, Willems T, De Ridder R, et al. Evaluating fracture risk in acute ankle sprains: Any news since the Ottawa Ankle Rules? A systematic review. *The European journal of general practice.* 2016;22(1):31-41.
33. de Cesar PC, Avila EM, de Abreu MR. Comparison of magnetic resonance imaging to physical examination for syndesmotic injury after lateral ankle sprain. *Foot Ankle Int.* 2011;32(12):1110-1114.
34. Sman AD, Hiller CE, Rae K, et al. Diagnostic accuracy of clinical tests for ankle syndesmosis injury. *British journal of sports medicine.* 2015;49(5):323-329.
35. van den Bekerom MP, Struijs PA, Blankevoort L, Welling L, van Dijk CN, Kerkhoffs GM. What is the evidence for rest, ice, compression, and elevation therapy in the treatment of ankle sprains in adults? *Journal of athletic training.* 2012;47(4):435-443.
36. Martin RL, Irrgang JJ, Burdett RG, Conti SF, Van Swearingen JM. Evidence of validity for the Foot and Ankle Ability Measure (FAAM). *Foot Ankle Int.* 2005;26(11):968-983.
37. Farrar JT, Young JP, Jr., LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain.* 2001;94(2):149-158.
38. Jensen MP, Turner JA, Romano JM. What is the maximum number of levels needed in pain intensity measurement? *Pain.* 1994;58(3):387-392.
39. Childs JD, Piva SR, Fritz JM. Responsiveness of the numeric pain rating scale in patients with low back pain. *Spine.* 2005;30(11):1331-1334.
40. Powden CJ, Hoch JM, Hoch MC. Reliability and minimal detectable change of the weight-bearing lunge test: A systematic review. *Man Ther.* 2015;20(4):524-532.
41. O'Shea S, Grafton K. The intra and inter-rater reliability of a modified weight-bearing lunge measure of ankle dorsiflexion. *Manual therapy.* 2013;18(3):264-268.
42. Vicenzino B, Branjerdporn M, Teys P, Jordan K. Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *The Journal of orthopaedic and sports physical therapy.* 2006;36(7):464-471.
43. Hoch MC, Andreatta RD, Mullineaux DR, et al. Two-week joint mobilization intervention improves self-reported function, range of motion, and dynamic balance in those with chronic ankle instability. *Journal of orthopaedic research: official publication of the Orthopaedic Research Society.* 2012;30(11):1798-1804.
44. Beazell JR, Grindstaff TL, Sauer LD, Magrum EM, Ingersoll CD, Hertel J. Effects of a proximal or distal tibiofibular joint manipulation on ankle range of motion and functional outcomes in individuals with chronic ankle instability. *The Journal of orthopaedic and sports physical therapy.* 2012;42(2):125-134.
45. Simondson D, Brock K, Cotton S. Reliability and smallest real difference of the ankle lunge test post ankle fracture. *Manual therapy.* 2012;17(1):34-38.
46. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *The Journal of orthopaedic and sports physical therapy.* 2006;36(12):911-919.
47. Dallinga JM, Benjaminse A, Lemmink KA. Which screening tools can predict injury to the lower extremities in team sports?: a systematic review. *Sports medicine.* 2012;42(9):791-815.
48. Shaffer SW, Teyhen DS, Lorenson CL, et al. Y-balance test: a reliability study involving multiple raters. *Military medicine.* 2013;178(11):1264-1270.
49. Gribble PA, Hertel J, Plisky P. Using the Star Excursion Balance Test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. *J Athl Train.* 2012;47(3):339-357.
50. Glasoe WM, Allen MK, Awtry BF, Yack HJ. Weight-bearing immobilization and early exercise treatment following a grade II lateral ankle sprain. *The Journal of orthopaedic and sports physical therapy.* 1999;29(7):394-399.
51. Tabrizi P, McIntyre WM, Quesnel MB, Howard AW. Limited dorsiflexion predisposes to injuries of the ankle in children. *The Journal of bone and joint surgery. British volume.* 2000;82(8):1103-1106.
52. O'Connor SR, Bleakley CM, Tully MA, McDonough SM. Predicting functional recovery after acute ankle sprain. *PloS one.* 2013;8(8):e72124.

APPENDIX A

General Management Guidelines Following Acute Lateral Ankle Sprain

1. Swelling management: Elevating the affected ankle above the level of the heart when at rest, using ice for 10-15 minutes 2-3 times per day, performing repeated dorsiflexion with gentle overpressure using a towel or strap (Figure 1) for assist and wearing an elastic tubular support bandage based on the amount of swelling at the ankle.

2. Ligament protection: Wearing a lace up ankle brace for twelve weeks throughout all waking hours. Avoiding ankle inversion and full plantar flexion for six weeks. Using crutches until gait was normal. Patients were instructed to wear supportive shoes that accommodated the brace and avoid wearing high heels or flip flops. Activity recommendations were made to limit activities that would potentially increase the risk of re-injury.

3. Tissue healing: Performing early dorsiflexion and plantarflexion ankle range of motion exercises 3-5 times per day, performed for a minimum of ten repetitions with a three second push or challenge to pain-free end range of movement to help maintain full range of motion. The normal gait pattern also provided a positive stimulus for ankle motion. Patients were also instructed to ride a stationary bike, typically starting with 10 minutes and progressed to 20-30 minutes in 2-5 minute increments. These sessions were performed 3-5 times per week as tolerated for the additional positive effects of controlled, repetitive ankle movement and to maintain leg strength and cardiovascular conditioning. The collective dose and effect of these activities on the injured ankle was monitored and adjusted by ongoing assessment of joint and soft tissue swelling, signs of inflammation, and pain.

4. Normal gait: In addition to crutches for early weight bearing as tolerated, patients performed progressive weight bearing range of motion exercises. These weight bearing exercises into repeated dorsiflexion were performed by standing with a towel under the foot on a smooth floor and sliding the foot back and forth with a non-painful amount of weight progressing to full weight bearing (Figure 2a/2b). Once a normal gait was achieved, patients were encouraged to walk as much as possible without increasing pain or swelling, with the intent of providing additional joint movement, stimulation of joint mechanoreceptors, and repetitive self-mobilization into ankle dorsiflexion (Figure 4).

5. Additional strategies to maintain and restore ankle range of motion: Joint and soft tissue mobilizations were applied at a grade and duration determined by the treating physical therapist. Early mobilizations focused on improving pain while facilitating early motion to the ankle and foot using Maitland grade III and IV mobilizations in early to mid-range resistance (up to 50% of range), starting with three to six bouts of 30 seconds while monitoring symptoms and overall tolerance to the treatment. Later mobilizations focused on addressing any persistent joint stiffness using mobilizations performed from mid to end range resistance and may have included thrust techniques, for a dose of up to 12 bouts of 30 seconds. Most joint mobilizations were performed at the talocrural, distal tibiofibular, and subtalar joints, but also included the metatarsals and proximal tibiofibular joints if they were movement limited or symptom producing. Manual soft tissue mobilizations targeted soft tissues potentially limiting range of motion or causing pain with movement or weight bearing. Nerve gliding techniques were used to mobilize potentially symptomatic peripheral nerves identified with palpation or neural tension tests. Active assisted movement strategies into dorsiflexion were progressed to standing calf stretches for three repetitions with a 30 second hold, and repeated dorsiflexion in standing for ten repetitions with a three second hold (Figures 3 and 4).

6. Strength and balance: Exercise was layered into clinical sessions and home programs once pain-free weight bearing and a non-antalgic gait were established, most typically in the third to fourth week after injury. Strengthening included heel-to-toe rocking and isolated heel lifts through full active range. Balance exercises started with

single limb stance, progressing from use of finger tips on a supportive surface for assistance to unassisted. Once patients demonstrated appropriate single leg static control the addition of sagittal plane movement with forward and backward reach and touch of the contralateral foot was introduced to challenge dynamic balance and control through the available ankle range of ankle motion. This type of balance exercise was frequently progressed to multi-angle contralateral foot reach and touch.

7. Home Exercise Program: All home-based exercises were instructed and performed at the initial dose during a clinical session to facilitate accurate performance and observe exercise tolerance. Home exercises were reviewed at every subsequent clinical session to promote adherence. The number of exercises and the dose of each exercise were slowly increased over the course of several appointments typically adding one to two exercises per appointment. Patients were also given an exercise folder containing printouts with detailed instructions for the exercise and a compliance log to track their adherence with the home exercise program. Patients who returned with their exercise folders, completed compliance logs, and could correctly demonstrate their home-exercise program were considered adherent. Patients who did not return with their completed log or failed to track their performance at home and could not appropriately demonstrate their home-exercise program were considered non-adherent with their home-exercise program. If a patient was considered non-adherent, additional education was provided on the importance of performing their home-exercise program and the patient was re-instructed in their home program.

8. Return to run and sport: A comprehensive return to running program, including specific warm-up exercises, walk-jog progression parameters, post-run strengthening exercises, and cool-down exercises, was carefully layered into later treatment sessions. The return to run program progressed patients through exercises that incorporated multiplane movements, single leg conditioning, and pivoting motions. Criteria for initiating the return to run program was a minimum of six weeks post injury, full ankle ROM, and the ability to maintain a normal, pain free walking gait for 30 minutes. Running was a goal of all the patients.

Reinforcing Movement Exercises

Figure 1. Self-stretch into dorsiflexion with strap. Patients were instructed to actively dorsiflex the ankle and use the strap to assist for full range. 10 repetitions of 3 second holds.

Figure 2a plantarflexion and Figure 2b dorsiflexion towel slides. Patients were instructed to maintain contact the towel with a flat foot as they slid the towel forward and backward in a pain-free range. 3 sets of 20 repetitions.

Figure 3a Gastrocnemius and 3b Soleus stretch in weightbearing position. Patients were instructed to keep the affected foot flat on the ground with toes pointed forward while they leaned forward until there was a gentle pull in the leg, but no ankle pain. For the gastrocnemius stretch patients kept the knee straight and for the soleus stretch they slightly bent the affected knee. 3 sets of 30 second holds.

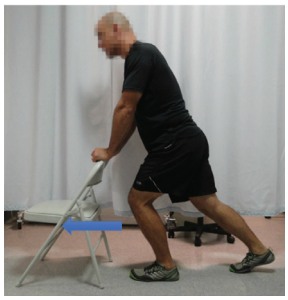


Figure 4. Repeated dorsiflexion in standing: Patients were instructed to place the affected foot forward with toes pointed straight ahead. The knee was moved forward over the toes while

maintaining heel contact with the floor. Patients were encouraged to move back and forth into dorsiflexion working into ankle tightness, but not pain. 3 sets of 30 repetitions.

Figure 5. Standing heel/toe rocking: This exercise was prescribed for repeated pain-free dorsiflexion and plantarflexion in weightbearing. Patients were instructed to stand with feet shoulder width apart while holding on to a stationary object for stability. The exercise was performed by rocking forward onto the toes then back onto heels while holding each position for 4-5 seconds. Range of motion was restricted if it was painful at either end of the exercise. 3 sets of 20 repetitions.

Strengthening Exercises

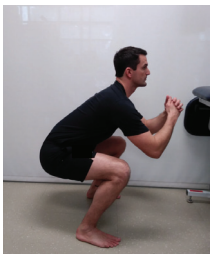


Figure 6. Body weight squats. Patients were instructed to squat as far as they could while maintaining contact with their heels on the ground. Depth was limited by available ankle dorsiflexion and pain. 3 sets of 20 repetitions.

Figure 7. Heel raises (Double leg progressing to single leg). Patients were instructed to slowly shift weight on to their toes, clearing their heels from the ground. Heel clearance was limited by available ankle plantarflexion and pain. Double leg heel raises were progressed to single leg once the patient demonstrated normal control throughout full plantarflexion ROM for all prescribed sets and repetitions. 3 sets of 20 repetitions.

Balance Exercises

Figure 8. Static single leg stance, using assistance as needed progressing to no assistance. Patients were instructed to shift all of their body weight onto the affected leg and lift the contralateral foot off the floor. Patients were allowed to use finger tips on a stationary object to assist with balance as needed, progressing to no assistance. 3 sets of 1-minute holds.

Figure 9. Single leg balance with forward and backward reach and touch of opposite leg. Patients were instructed to maintain balance on the affected leg and reach forward and back ward as far as they could with the contralateral foot. After tapping toes to the ground patients returned to the start position and maintained the single leg stance. 3 sets of 10 repetitions.

General Guidelines for Joint Mobilizations Following Acute Lateral Ankle Sprain

- Joint mobilization techniques
  - Perform with respect for the patients symptoms and should be consistent with the stages of ligamentous healing.
  - If symptoms are aggravated, they should be minimal and ease quickly.
  - Addressing dorsiflexion impairments should be prioritized early.
  - Consider joint position during treatment ensuring inversion is avoided for 6 weeks.
  - Limit inversion stiffness by assessing the subtalar joint and treating impairments if present in a neutral position.
- Dosage
  - Initial dose should be 3-6 bouts of 30-60 seconds to assess and understand patient tolerance and influence on specific impairments.

- Dose should be progressed over time, often reaching 12-15 bouts during subsequent treatment sessions.
- Grade (I-IV) or vigor of mobilization should be progressed with consideration of patient symptoms and stage of tissue healing. Typically grades III and IV, into early to mid-range resistance (up to 50% of range), are recommended if well tolerated.

- Reinforcing movement
  - Manual physical therapy techniques should be reinforced with exercises that reinforce joint mobility and when possible provide similar movement to the joint mobilization.

Manual Therapy Techniques

Figure 10a Ankle Distraction mobilization/ manipulation and 10b Ankle Distraction with alternate hand position.

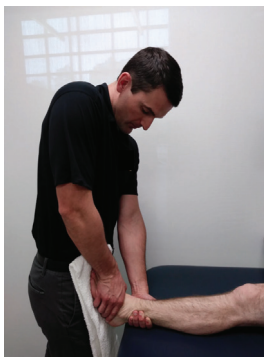
Patient position: Supine with heel off the table.

Therapist position: Grasp the patient's foot, with proximal fingers distal to the neck of the talus.

Provide firm pressure with thumbs in the plantar surface of the forefoot to create dorsiflexion of the ankle.

Mobilization technique: Engage the restrictive barrier with ankle dorsiflexion and long-axis distraction. Apply a graded mobilization (I-IV) or a thrust manipulation in a caudal and dorsiflexed direction.

Figure 11. Talocrural anterior to posterior mobilization.

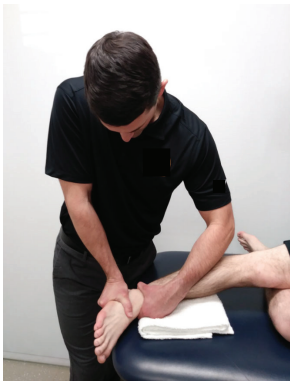


Patient Position: Supine with heel off the table.

Therapist Position: Proximal hand stabilizes the leg by positioning on hand just proximal to the malleoli. The distal mobilizing hand cups the anterior talus in the first web space. The thigh may be used to stabilize the foot and to add dorsiflexion.

Mobilization Technique: Mobilize with a posterior force on the talus into the restrictive barrier. Progressively increase dorsiflexion as tolerated.

Figure 12: Medial Subtalar Mobilization.



Patient Position: Sidelying on unaffected side with affected ankle off the table.

Therapist Position: Proximal hand stabilizes the distal leg by grasping the talus just distal to malleoli. The non-mobilizing arm rests on the patients lateral leg for added support.

The distal mobilizing hand grasps the talus with the heel of the hand over the calcaneus.

Mobilization Technique: Graded medial mobilization is applied by moving the calcaneus downward toward the floor.

Figure 13. Ankle dorsiflexion with talocrural anterior to posterior glide – mobilization with movement.

Patient Position: Half kneeling on the table with the affected foot forward.

Therapist Position: Hands stabilize the foot on the table as close to the talocrural joint as possible. The mobilization belt is placed around the distal leg proximal to the malleoli and around the therapist's hips. The therapist uses body weight through the belt to provide an anterior glide of the distal tibia and fibula on the talus.

Mobilization Technique: The patient is asked to lung forward while keeping the heel down into the pain-free restrictive barrier for 3 sets of 10 repetitions.